

CLAIMS

Therefore, having thus described the invention, at least the following is claimed:

- 1 1. An output stage for a line driver, comprising:
2 a first amplifier comprising a series combination of a first semiconductor device
3 and a second semiconductor device;
4 a second amplifier comprising a series combination of a third semiconductor
5 device and a fourth semiconductor device;
6 a first integrated back-matching resistor network interposed between the first and
7 the second semiconductor devices; and
8 a second integrated back-matching resistor network interposed between the third
9 and the fourth semiconductor devices.
- 1 2. The line driver of claim 1, wherein the first integrated back-matching
2 resistor network comprises a series combination of integrated resistors having an additive
3 resistance selected to match an expected load input impedance.
- 1 3. The line driver of claim 2, wherein the second integrated back-matching
2 resistor network comprises a series combination of integrated resistors having an additive
3 resistance selected to emulate an expected line input impedance.
- 1 4. The line driver of claim 3, wherein the series combination of integrated
2 resistors selected to match the expected load input impedance are configured in parallel
3 with the series combination of integrated resistors selected to emulate the expected line
4 input impedance.

1 5. The line driver of claim 4, wherein a supply voltage applied to a source
2 node of the first and second semiconductor devices of the first and second amplifiers
3 respectively, is increased to a voltage level exceeding the maximum drain-source voltage
4 for the semiconductor device technology associated with the first and second
5 semiconductor devices, resulting in an available maximum power increase at the line
6 driver output.

1 6. The line driver of claim 5, wherein the available maximum power increase
2 at the line driver output is realizable without increasing the maximum current in the line
3 driver output stage.

1 7. The line driver of claim 5, wherein the first, second, third, and fourth
2 semiconductor devices are standard CMOS devices.

1 8. The line driver of claim 7, wherein the first and third semiconductor
2 devices are PMOS transistors.

1 9. The line driver of claim 7, wherein the second and fourth semiconductor
2 devices are NMOS transistors.

1 10. The line driver of claim 7, wherein the standard CMOS devices have a
2 maximum drain-source voltage of approximately 5 Volts.

1 11. The line driver of claim 10, wherein the power supply maximum voltage is
2 approximately 20/3 Volts.

1 12. The line driver of claim 11, wherein the effective signal swing across a
2 load is approximately 10/3 Volts.

1 13. The line driver of claim 11, wherein the effective power gain available at
2 the output of the line driver is greater than approximately 2.5 dB larger than the effective
3 power gain of a conventional line driver.

1 14. The line driver of claim 13, wherein the effective power gain available at
2 the output of the line driver is approximately 3.0 dB larger than the effective power gain
3 of a conventional line driver.

1 15. An output stage for a line driver, comprising:
2 a first amplifier comprising a series combination of a first semiconductor device
3 and a second semiconductor device;
4 a second amplifier comprising a series combination of a third semiconductor
5 device and a fourth semiconductor device;
6 a first integrated back-matching resistor interposed between the first and the
7 second semiconductor devices and a first line driver output node;
8 a second integrated back-matching resistor interposed between the third and the
9 fourth semiconductor devices and a second line driver output node;
10 a first supply voltage protective semiconductor device interposed in series
11 between the first semiconductor device and the first integrated back-matching resistor;
12 a second supply voltage protective semiconductor device interposed in series
13 between the first integrated back-matching resistor and the second semiconductor device;
14 a third supply voltage protective semiconductor device interposed in series
15 between the third semiconductor device and the second integrated back-matching resistor;
16 and
17 a fourth supply voltage protective semiconductor device interposed in series
18 between the second integrated back-matching resistor and the fourth semiconductor
19 device.

1 16. The line driver of claim 15, wherein the sum of the resistance values of the
2 first and the second integrated back-matching resistors is selected to match an expected
3 load input impedance.

1 17. The line driver of claim 15, wherein the first and second supply voltage
2 protective semiconductor devices comprise at least one source follower.

1 18. The line driver of claim 15, wherein the first and second supply voltage
2 protective semiconductor devices protect only a respective semiconductor device that is
3 idle.

1 19. The line driver of claim 16, wherein the first and second integrated back-
2 matching resistors have a resistance of approximately the same value.

1 20. The line driver of claim 19, wherein a supply voltage is increased to a
2 voltage level exceeding the maximum drain-source voltage for the semiconductor device
3 technology associated with the first, second, third, and fourth semiconductor devices,
4 resulting in an available maximum power increase at the line driver output.

1 21. The line driver of claim 20, wherein the available maximum power
2 increase at the line driver output is realizable without increasing the maximum current in
3 the line driver output stage.

1 22. The line driver of claim 21, wherein the power supply maximum voltage is
2 approximately twice the maximum drain-source voltage of the semiconductor device
3 technology of the first, second, third, and fourth semiconductor devices.

1 23. The line driver of claim 15, wherein the first, second, third, and fourth
2 semiconductor devices are standard CMOS devices.

1 24. The line driver of claim 23, wherein the standard CMOS devices have a
2 maximum drain-source voltage of approximately 5 Volts.

1 25. The line driver of claim 24, wherein the power supply maximum voltage is
2 approximately 10 Volts.

1 26. The line driver of claim 25, wherein the first and third semiconductor
2 devices are PMOS transistors.

1 27. The line driver of claim 25, wherein the second and fourth semiconductor
2 devices are NMOS transistors.

1 28. The line driver of claim 25, wherein the first and third supply voltage
2 protective semiconductor devices are PMOS transistors.

1 29. The line driver of claim 25, wherein the second and fourth supply voltage
2 protective semiconductor devices are NMOS transistors.

1 30. The line driver of claim 25, wherein the effective signal swing across a
2 load is approximately equivalent to the full power supply voltage range.

1 31. The line driver of claim 25, wherein the effective power gain available at
2 the output of the line driver is approximately 6.0 dB larger than the effective power gain
3 of a conventional line driver.

1 32. An output stage for a line driver, comprising:
2 a first amplifier comprising a series combination of a first semiconductor device, a
3 first semiconductor protective device, a second semiconductor device, and a second
4 semiconductor protective device, wherein the first and second semiconductor protective
5 devices are interposed between the first semiconductor device and the second
6 semiconductor devices;
7 a second amplifier comprising a series combination of a third semiconductor
8 device, a third semiconductor protective device, a fourth semiconductor device, and a
9 fourth semiconductor protective device, wherein the third and fourth semiconductor
10 protective devices are interposed between the third semiconductor device and the fourth
11 semiconductor devices;
12 a first integrated back-matching resistor network interposed between the first
13 semiconductor protective device and a first pole of a transformer;
14 a second integrated back-matching resistor network interposed between the first
15 pole of the transformer and the second semiconductor protective device;
16 a third integrated back-matching resistor network interposed between the third
17 semiconductor protective device and a second pole of the transformer; and
18 a fourth integrated back-matching resistor network interposed between the second
19 pole of the transformer and the fourth semiconductor protective device.

1 33. The line driver of claim 32, wherein the first, second, third, and fourth
2 integrated back-matching resistor networks comprise a combination of integrated resistors
3 having a resistance selected to match an expected load input impedance.

1 34. The line driver of claim 32, further comprising:
2 a first integrated resistor having a resistance selected to emulate an expected line
3 input impedance interposed between the first and the second integrated back-matching
4 resistor networks; and
5 a second integrated resistor having a resistance selected to emulate an expected
6 line input impedance interposed between the third and the fourth integrated back-
7 matching resistor networks.

1 35. The line driver of claim 32, wherein a supply voltage applied to a source
2 node of the first and third semiconductor devices is increased to a voltage level exceeding
3 the maximum drain-source voltage for the semiconductor device technology associated
4 with the first, second, third, and fourth semiconductor devices, resulting in an available
5 maximum power increase at the line driver output.

1 36. The line driver of claim 35, wherein the available maximum power
2 increase at the line driver output is realizable without increasing the maximum current in
3 the line driver output stage.

1 37. The line driver of claim 36, wherein the first, second, third, and fourth
2 semiconductor devices are standard CMOS devices.

1 38. The line driver of claim 37, wherein the standard CMOS devices have a
2 maximum drain-source voltage of approximately 5 Volts.

1 39. The line driver of claim 37, wherein the power supply maximum voltage is
2 approximately 40/3 Volts.

1 40. The line driver of claim 37, wherein the first and third semiconductor
2 devices are PMOS transistors.

1 41. The line driver of claim 37, wherein the second and fourth semiconductor
2 devices are NMOS transistors.

1 42. The line driver of claim 37, wherein the first and third supply voltage
2 protective semiconductor devices are PMOS transistors.

1 43. The line driver of claim 37, wherein the second and fourth supply voltage
2 protective semiconductor devices are NMOS transistors.

1 44. The line driver of claim 39, wherein the effective signal swing across a
2 load is approximately 20/3 Volts.

1 45. The line driver of claim 39, wherein the effective power gain available at
2 the output of the line driver is greater than approximately 8.5 dB larger then the effective
3 power gain of a conventional line driver.

1 46. The line driver of claim 39, wherein the effective power gain available at
2 the output of the line driver is approximately 9.0 dB larger then the effective power gain
3 of a conventional line driver.

1 47. An integrated circuit line driver, comprising:
2 means for increasing the effective output signal swing to at least a voltage level
3 that exceeds the maximum drain-source voltage of the integrated circuit technology.

1 48. The line driver of claim 47, wherein the means for increasing the effective
2 output signal swing is accomplished with an integrated resistor network.

1 49. The line driver of claim 47, wherein the means for increasing the effective
2 output signal swing is accomplished with a combination of protective semiconductor
3 devices and a plurality of integrated back-matching resistors.

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1 50. The line driver of claim 47, wherein the protective semiconductor devices
2 comprise at least one source follower.

1 51. The line driver of claim 49 wherein the protective semiconductor devices
2 protect a semiconductor device that is idle.

1 52. A transmission unit, comprising:
2 a line driver having an output stage, wherein the output stage is configured to
3 transmit a signal having a peak-to-peak voltage swing that exceeds the maximum drain-
4 source voltage of the integrated circuit technology used to implement the line driver.

1 53. A communications system, comprising:
2 a transmission unit having an integrated line driver, the integrated line driver
3 having an output stage, wherein the output stage is configured to transmit a signal having
4 a peak-to-peak voltage swing that exceeds the maximum drain-source voltage of the
5 integrated circuit technology used to implement the line driver.

1 54. A method of increasing the available signal transmit power on a
2 transmission line, comprising:
3 applying a transmit signal to an input stage of an integrated line driver;
4 amplifying the transmit signal such that the output signal swing exceeds the
5 maximum drain-source voltage of the integrated circuit technology used to implement an
6 at least one amplifier in an integrated line driver output stage; and
7 applying the amplified transmit signal via an integrated resistor network to the
8 transmission line.

1 55. The method of claim 54, wherein the integrated resistor network
2 comprises:
3 a parallel combination of a first resistor branch comprising an at least balanced
4 pair of integrated resistors selected to match an expected load impedance.

1 56. The method of claim 54, wherein the integrated resistor network
2 comprises:
3 a pair of integrated back-matching resistors selected such that the sum of their
4 resistance values approximates an expected load impedance, wherein each of the
5 integrated back-matching resistors supplies half of the available signal transmit power to
6 a load.

1 57. The method of claim 54, wherein the step of amplifying the transmit signal
2 is accomplished by adding a plurality of protective semiconductor devices, wherein each
3 of the plurality of protective semiconductor devices protects a corresponding
4 semiconductor device when the corresponding semiconductor device is idle.

1 58. The method of claim 57, wherein each of the plurality of protective
2 semiconductor devices comprise at least one source follower.